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EXAMINER
KIELIN, ERIK J

ART UNIT	PAPER NUMBER
2813	

DATE MAILED: 05/03/2002

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/597,076	Applicant(s) CHEN ET AL.	
	Examiner Erik Kielin	Art Unit 2813	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *11 February 2002* .

2a)☐ This action is **FINAL**. 2b)☒ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *1-31* is/are pending in the application.

4a) Of the above claim(s) *28 and 29* is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *1-25,30 and 31* is/are rejected.

7)☒ Claim(s) *26 and 27* is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☒ The specification is objected to by the Examiner.

10)☒ The drawing(s) filed on *20 June 2000* is/are: a)☐ accepted or b)☒ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11)☐ The proposed drawing correction filed on _____ is: a)☐ approved b)☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12)☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____ .

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

14)☒ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).

a) ☐ The translation of the foreign language provisional application has been received.

15)☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) *9,10* .
4) ☐ Interview Summary (PTO-413) Paper No(s). _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Election/Restrictions

Applicant's election without traverse of group I, claims 1-27, 30, and 31, in Paper No. 13 is acknowledged.

Drawings

1. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(4) because reference characters "21" "22" "23" "24" "25" "26" "27" "28" have been used to designate both parts of a transistor (in Fig. 1B) and steps in a time-temperature profile (in Fig. 2B).

2. Figure 6 should be designated by a legend such as --Prior Art-- because only that which is old is illustrated. See MPEP § 608.02(g).

3. The drawings are objected to as failing to comply with 37 CFR 1.84(p)(5) because they include the following reference sign(s) not mentioned in the description: 99. It appears that this reference character should be "119" to be consistent with the specification. (See p. 13, last paragraph.)

4. A proposed drawing correction, corrected drawings, or amendment to the specification to add the reference sign(s) in the description, are required in reply to the Office action to avoid abandonment of the application. The objection to the drawings will not be held in abeyance.

Specification

5. The disclosure is objected to because of the following informalities:

on p. 2, line 19, remove "a" for clarity;

on p. 7, line 18, replace "Dichloroethyline" with --Dichloroethylene-- for correct spelling;

on p. 8, lines 28-35, Applicant states that because the second oxide portion 32 is more amorphous, and this amorphous nature "results in a denser oxide" and then continues stating "[t]he random nature of the molecular structure of the second oxide portion 32 results in a more densely packed oxide." These statements are grossly in error. First, the vast majority, if not all, materials are at their highest density when in a perfect crystal arrangement because crystalline arrangements allow maximum packing of atoms in a lattice. Amorphous structures, to the contrary, have no crystalline order (i.e. voids), which would be otherwise occupied by atoms. Accordingly, amorphous materials are, in general *less* dense -- not *more* dense -- than crystalline materials. In support of this point as particularly relevant to the instant application, Ghandi (VLSI Fabrication Principles, 2nd ed. John Wiley & Sons: New York, 1994, p. 453) states, "Silica films, as grown by oxidation of the silicon surface, are amorphous in nature, and consist of random network of such polyhedra. Typically they have a density of 2.15 - 2.25 as compared to 2.65 for single-crystal quartz..." Clearly, thermally produced silicon dioxide is less dense, not more dense, than crystalline silicon dioxide. Accordingly, the statement regarding the bond length being shorter due to the amorphous nature is also grossly in error.

On p. 14, line 31, replace "137" with --136-- for consistency with Fig. 14.

Appropriate correction is required.

6. The title of the invention is not descriptive. A new title is required that is clearly indicative of the invention to which the claims are directed.

The following title is suggested:

A TWO-STEP THERMAL GROWTH PROCESS FOR GATE OXIDE FABRICATION USING A FIRST OXIDATION STEP BELOW AND A SECOND OXIDATION STEP ABOVE THE VISCOELATIC TEMPERATURE OF SILICON DIOXIDE.

Claim Rejections - 35 USC § 112

7. The following is a quotation of the first paragraph of 35 U.S.C. 112:

> The specification shall contain a written description of the invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to make and use the same and shall set forth the best mode contemplated by the inventor of carrying out his invention.

8. Claims 3, 5, 6, 7-11, 13, 14, 17-19, 21, 22, and 31 are rejected under 35 U.S.C. 112, first paragraph, as containing subject matter which was not described in the specification in such a way as to enable one skilled in the art to which it pertains, or with which it is most nearly connected, to make and/or use the invention.

In each of claims 3, 7, 13, 17, 21, and 22, as presently written, require changing (heating or cooling) the substrate temperature in a two-step process, but requires each step to start from the same "ambient temperature." This is impossible because the temperature has already changed in the first step from the ambient temperature to some different temperature. Accordingly, the substrate can no longer be at "said ambient temperature."

For example, claim 13 states in the first cooling step that the substrate temperature is cooled from "*an* ambient temperature ... to an intermediate temperature." After this first step, then, the substrate must be at the *intermediate temperature*. The second step then requires the temperature of the substrate to again be lowered from "*said ambient temperature* ... to a final temperature," but the substrate in not at "said ambient temperature;" Instead, as indicated, it is at

the "intermediate temperature" as a result of the first cooling step. Accordingly, the method cannot be performed as presently claimed.

Examiner assumes that Applicant means that in the second of the two-step heating and cooling processes that, in the second step, the substrate temperature changed from whatever temperature is was taken to in the first of the two steps. For the purposes of patentability, Examine assumes that this is what Applicant is claiming, because this is supported by the specification and figures.

Claims 5, 6, 8-11, 14, 18, 19, and 31 are rejected for depending from claims 3, 7, 13, 17, 21, and 22.

9. Claim 12 is rejected under 35 U.S.C. 112, first paragraph, because the specification, while being enabling for some non-zero amount of oxygen up to 25%, does not reasonably provide enablement for 0% oxygen. The specification does not enable any person skilled in the art to which it pertains, or with which it is most nearly connected, to use the invention commensurate in scope with these claims. In order to oxidize silicon, some oxygen must be present, otherwise there exists no oxidant. Accordingly, 0% oxygen does not constitute an oxidizing ambient.

Claim Rejections - 35 USC § 102

10. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

> (e) the invention was described in a patent granted on an application for patent by another filed in the United States before the invention thereof by the applicant for patent, or on an international application by another who has fulfilled the requirements of paragraphs (1), (2), and (4) of section 371(c) of this title before the invention thereof by the applicant for patent.

The changes made to 35 U.S.C. 102(e) by the American Inventors Protection Act of 1999 (AIPA) do not apply to the examination of this application as the application being examined was not (1) filed on or after November 29, 2000, or (2) voluntarily published under 35 U.S.C. 122(b). Therefore, this application is examined under 35 U.S.C. 102(e) prior to the amendment by the AIPA (pre-AIPA 35 U.S.C. 102(e)).

11. Claims **1**-4, 6-11, 13-14 and **16**, 17, 19, 20, 23, 30 rejected under 35 U.S.C. 102(e) as being anticipated by US 6,316,300 B1 (**Ozeki** et al.).

Regarding claims 1, 2, 4, 16, 20, 23, and 30, **Ozeki** discloses a process for fabricating an oxide comprising (a) forming a first oxide portion **6a** over a silicon substrate by oxidation at a first temperature of 875 °C which is below the viscoelastic threshold temperature (925 °C as indicated in the instant specification at p. 8, lines 25-27); (b) forming a second oxide portion **6** under said first oxide portion by oxidation at a temperature of 1050 °C; and (c) cooling said substrate at a controlled rate of 3 °C/min to a temperature below the viscoelastic temperature (800 °C) so that said first oxide portion acts as a stress sink for said second oxide portion, as indicated by Applicant in the specification at p. 9, lines 1-15. (See Figs. 6A-6B and associated text col. 8, line 36 to col. 9, line 34.)

Regarding claims 3, 6, 17, and 19, the silicon substrate is heated from the initial temperature of normal room temperature wafer to 800 °C ("the first temperature") at a first rate,

and then to 875 °C ("the temperature below the threshold temperature [of 925 °C]") at a rate of 10 °C/min (col. 8, lines 43-46).

Regarding claims 7-10, the ambient temperature is 875 °C, the first rate and second rates are 10 °C/min, as further limited in claims 9 and 10, and the temperature above the threshold temperature is 1050 °C, as further limited by instant claim 8 (col. 9, lines 1-5). Note that there is no requirement disclosed or claimed that the first and second rates be different. Rather the claims 9 and 10 clearly indicate that the rates are exactly the same over most of the claimed ranges.

Regarding claim 11, the oxidizing ambient is oxygen and/or steam (Fig. 6B; col. 8, lines 53-67.)

Regarding claims 13 and 14, the temperature is reduced from 1050 °C to 800 °C at 3 °C/min and then "unloaded from the oxidation reactor" which will result in the cooling at a second rate to normal room temperature (Fig. 6A; col. 9, lines 26-33).

12. Claims **1**, 2, 4, 7-11, 13, 14, and **16**, 20, 23, 30 are rejected under 35 U.S.C. 102(b) as being anticipated by US 4,518,630 (**Grasser** et al.).

Regarding claims 1, 2, 4, 16, 20, 23, and 30, **Grasser** discloses a process for fabricating an oxide comprising (a) forming a first oxide portion over a silicon substrate by oxidation at a first temperature of 700-900 °C which is below the viscoelastic threshold temperature of 925 °C to form an oxide portion 1 nm (10 Å) thick (Fig.; col. 2, lines 60 to end); (b) forming a second oxide portion under said first oxide portion by oxidation at a temperature of 1000 °C in an oxidizing ambient of oxygen; and (c) eventually cooling the wafer to a temperature of 850 °C below the threshold temperature at a rate of 1.7 to 3.3 °C/min as is clear from the data and then

"taken out" of the furnace which allows cooling at a second rate, as further limited by claims 13 and 14 (col. 3, lines 33-39). (See Fig. and col. 2, line 50 to col. 3, line 64.)

Regarding claims 7-10, the ambient temperature is 700-900 °C, the first rate and second rates are 10 °C/min, as further limited in claims 9 and 10, and the temperature above the threshold temperature is 1000 °C, as further limited by instant claim 8 (col. 3, lines 20-26). Note that there is no requirement disclosed or claimed that the first and second rates be different. Rather the claims 9 and 10 clearly indicate that the rates are exactly the same over most of the claimed ranges.

Regarding claim 11, the oxidizing ambient is oxygen and/or steam (col. 3, lines 15-16).

13. Claims **1**, 4 and **16**, 20, 23, 30 are rejected under 35 U.S.C. 102(b) as being anticipated by US 4,826,779 (**Wright** et al.).

Wright discloses a process for fabricating an oxide comprising (a) forming a first oxide portion **32a-c** over a silicon substrate by oxidation at a first temperature of 900 °C which is below the viscoelastic threshold temperature (925 °C); (b) forming a second oxide portion **36a-c** under said first oxide portion by oxidation at a temperature of 1050 °C in an oxidizing ambient of 10% oxygen; and (c) eventually cooling the wafer to a temperature below the threshold temperature. (See Figs. 2-3; col. 4, lines 11-35.)

Claim Rejections - 35 USC § 103

14. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

15. Claims 3 and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Grasser** in view of US 5,817,581 (**Bayer** et al.).

The prior art of **Grasser**, as explained above, discloses each of the claimed features except for using a first and a second rate to heat the substrate to the temperature below the threshold temperature of 700-900 °C.

Bayer teaches a multi-step oxidation process wherein the is heated to the first low oxidation temperature (the temperature below the threshold temperature of 925 °C) at a first rate of 7 °C/min and then a second rate of 1 °C/min, which provides better temperature control and prevents overshooting the temperature. (See col. 2, lines 18-27.)

It would be obvious for one of ordinary skill in the art, at the time of the invention, to use a two-rate heating process as taught by **Bayer** to heat to the first oxidation temperature in **Grasser** in order to provides a faster heating process than using a single rate and to provide better temperature control which prevents overshooting the temperature, as is clear from the teaching in **Bayer**.

16. Claims 7, 8, 11, 12, and 17 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Wright** in view of **Grasser**.

The prior art of **Wright**, as explained above, discloses each of the claimed features except for using a first and a second rate to heat the substrate to the temperature below the threshold temperature of 900 °C.

Regarding claim 7, **Grasser** teaches a multi-step oxidation process, as noted above, wherein the temperature between oxidation portions is raised at a first and second rate of 10 °C/min, as noted above.

It would be obvious for one of ordinary skill in the art, at the time of the invention, to use the heating process as taught by **Grasser** to heat from the first oxidation temperature in **Wright** to the second oxidation temperature in **Wright**, because **Wright** does not specify a heating rate, so that one of ordinary skill in the art would be especially motivated to find a reasonable heating rate to provide good gate oxide characteristics as taught in the **Grasser** method.

Regarding claims 8, 11 and 12, which depend from claim 7, each of these features is disclosed in **Wright**, as indicated above.

17. Claims 5, 18, 22, and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Ozeki** in view of US 6,207,591 B1 (**Aoki** et al.).

The prior art of **Ozeki**, as explained above, discloses each of the claimed features except for indicating a first heating rate of 50 °C to 125 °C to the disclosed first temperatures in the range of 750 °C to 850 °C.

Aoki teaches that conventional furnaces typically heat at rates of 1 °C/min to 100 °C/min, typically at 50 °C/min to reach an initial heating temperature. **Aoki** also teaches that conventional furnaces typically cool at 50 °C/min. **Aoki** also teaches that stepwise changes in the heating a

cooling rates conventionally depend upon the "temperature region of the heating and cooling operation" as has already been shown in the applied art. (See paragraph bridging cols. 1-2, and prior art Fig. 1.)

It would be obvious for one of ordinary skill in the art, at the time of the invention, to modify the heating rate of **Ozeki** for the heating to the first heating temperature of 800 °C taught therein, at a first rate of 50 °C/min or 100 °C/min and to cool at the second rate of the wafer pull at 50 °C/min, both as taught in **Aoki**, because **Ozeki** does not teach what the first heating rate or the second cooling rate is, so that one of ordinary skill would be motivated to find and to use conventional rates which provide good results, such as the conventional rates, and because the rates are high which would reduce thermal budget which is always highly desired in the art.

18. Claims 5, 18, 22, 25 and 31 are rejected under 35 U.S.C. 103(a) as being unpatentable over **Grasser** in view of **Bayer** as applied to claims 1, 3, 16, and 17 above, and further in view of US 6,207,591 B1 (**Aoki** et al.).

The prior art of **Grasser** in view of **Bayer**, as explained above, discloses each of the claimed features except for indicating a first heating rate of 50 °C to 125 °C to the disclosed first temperatures in the range of 750 °C to 850 °C.

Aoki is applied as above.

Regarding claim 25, note that **Grasser** teaches that the first oxide portion is 1 nm (10 Å), as noted above.

19. Claims 15 and 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over any of **Ozeki**, **Wright**, and **Grasser**, any in view of This application is claiming the benefit of a prior filed nonprovisional application under 35 U.S.C. 120, 121, or 365(c).

The prior art of each of **Ozeki**, **Grasser**, and **Bayer**, as explained above, discloses each of the claimed features except for indicating that the silicon substrate is monocrystalline.

Wolf teaches the benefits of using monocrystalline silicon to form semiconductor devices because monocrystalline has higher carrier mobility than in polycrystalline silicon thereby affording higher speed devices, which is always highly desired in the art.

It would be obvious for one of ordinary skill in the art, at the time of the invention, to use monocrystalline silicon as the substrates in any of **Ozeki**, **Wright**, and **Grasser** to have higher speed devices as taught by **Wolf**.

Allowable Subject Matter

20. Claims 21, 26, and 27 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. Claim 21 also requires overcoming the rejection under 35 USC 112(1), as noted above.

The following is a statement of reasons for the indication of allowable subject matter:

Regarding claim 21, the prior art of record does not fairly teach or suggest the specific combination of steps claimed therein, in combination with the other claimed features. Note however, that **Ozeki** does teach the first two steps recited in instant claim 21, wherein the oxygen concentration during the heating rates is between 0-5% oxygen, but fails to teach that the oxygen

concentration of 0-25% is used to form the second oxide portion. **Ozeki** uses higher concentrations of oxygen during the second oxidation step.

Regarding claim 26, although Grasser teaches that the first portion of the oxide is 10 Å, Grasser also teaches that a second portion of 1 nm is grown during the ramp from the first oxidation temperature to second, and that a third portion is grown to a desired thickness of 50 100 Å which would require the oxidation at the higher portion to be formed to a minimum of 30 Å which is not in the range of 2-12 Å.

Regarding claim 27, the prior art of record does not teach forming a 15 Å oxide using the two-step oxidation process as claimed.

Conclusion

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Erik Kielin whose telephone number is 703-306-5980. The examiner can normally be reached on 9:00 - 19:30 on Monday through Thursday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri can be reached at 703-306-2417. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9318 for regular communications and 703-872-9319 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0956.

Erik Kielin
April 23, 2002